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The Progress of Regulations to Protect Stratospheric Ozone: Report to Congress

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U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF TOXIC SUBSTANCES
401 M Street, S.W.
Washington, D.C. 20460

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As mandated by Section 155 of the Clean Air Act Amendments of 1977, EPA has submitted to Congress in February 1982, a report on the progress of regulation to protect stratospheric ozone covering the period from August 1979 to December 1981. The report reviews activities related to the production of stratospheric ozone from potential depletion due to emissions of chlorofluorocarbons (CFCs) and other ozone-depleting substances. Although the 1978 EPA & FDA regulations prohibited the manufacturing and processing of CFCs for non-essential aerosol uses, anticipated market growth in some non-aerosol uses may eventually offset the reductions achieved by the aerosol rule. In addition to CFCs, other potential ozone depleting substances are being investigated by EPA and other agencies. At the international level Japan and the European Economic Community have limited CFC-11 and CFC-12 production capacity to present levels while several nations are assessing the feasibility of reducing emissions from other uses. EPA and other Federal agencies will continue to monitor and support research to improve our understanding of atmospheric, health & environmental science of ozone depletion, technological capabilities and costs for limiting CFC emissions. Any decision regarding EPA action would be based on an evaluation of all these factors.

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SUMMARY

As mandated by Section 155 of the Clean Air Act Amendments of 1977, PL 95-95 (CAA), the Environmental Protection Agency (EPA) submits to Congress this report on the progress of regulation to protect stratospheric ozone covering the period from August 1979 to December 1981. Section 155 requires that the Administrator report to Congress on actions taken by the Environmental Protection Agency and other Federal agencies to regulate sources of halocarbon emissions, the results of such regulations in protecting the ozone layer, the need for additional regulatory action, if any, and recommendations for control of substances, practices, processes, or activities other than those involving halocarbons which affect stratospheric ozone and cause or contribute to harmful effects on public health or welfare.

This report reviews activities related to the protection of stratospheric ozone from potential depletion due to emissions of chlorofluorocarbons (CFCs) and other ozone-depleting substances. If ozone concentrations are reduced, increased amounts of solar ultraviolet radiation in the wavelength region of 290-320 nanometers (UV-B) would reach the earth's surface. This may have a number of consequences, including higher incidence of nonmelanoma skin cancer among humans, decreased plant productivity, and adverse effects on the aquatic food chain.

In March 1978, the Food and Drug Administration (FDA) and EPA promulgated rules that prohibited the manufacturing and processing of CFCs for nonessential aerosol propellant uses. Domestic CFC use as aerosol propellants was about 448 million pounds in 1973. In 1980 aerosol uses accounted for about 24.5 million pounds out of a total of 835 million pounds produced domestically. However, nonaerosol uses of CFC, including solvents, blowing and insulating agents in foam manufacturing, refrigeration, air conditioning, and other specialized processes, increased between 1975 and 1979 and then fell slightly in the

1979-80 economic slowdown. Anticipated recovery of the economy combined with expected market growth in some uses of CFCs may eventually offset the reductions achieved by the aerosol rule.

In October 1980, EPA issued an Advance Notice of Proposed Rulemaking (ANPR) requesting public comment about possible effects on human health and the environment from the continuing use of CFCs, and on the economic aspects of the issue. The ANPR solicited comments on the validity of the ozone depletion theory, and the effectiveness of restricting the use of CFCs as a means of dealing with any significant problem. Also in 1980, EPA issued a proposed rule under authority of Part A of the CAA Amendments of 1977 which would regulate emissions of certain solvents including CFC-113 and other substances which may deplete ozone from new, modified, or reconstructed organic solvent cleaners. EPA is currently studying whether to include these degreasing solvents in a final rule.

In addition to CFCs, other potential ozone depleting substances are being investigated by EPA and other agencies. For example, EPA recently completed an analysis of production and emissions of methyl chloroform. Other agencies, including the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, and the Department of Energy, are investigating the effects on stratospheric ozone of compounds other than CFCs, including other halocarbons, carbon dioxide, and nitrogen oxides.

Because CFC emissions in any country may be dispersed throughout the earth's atmosphere, the protection of stratospheric ozone is an international issue. A few countries have prohibited most aerosol propellant uses and many CFC-producing and using nations have achieved reductions in aerosol propellant uses by regulatory or voluntary actions. Several nations are assessing the feasibility of reducing emissions from other uses. Japan and the European Economic Community have limited CFC-11 and CFC-12 production capacity to present levels. The U.S. is participating in a number of international

organizations which promote, coordinate, and assess research and study technical and economic aspects of the CFC/ozone depletion issue.

To fulfill the requirements of the CAA Amendments of 1977 and to improve and expand the scientific basis for evaluating the necessity of further reductions in CFC emissions, EPA and other Federal agencies are continuing to monitor and support research related to improving our understanding of atmospheric science, adverse health and environmental consequences of ozone depletion, technological capabilities for limiting CFC emissions from major sources, and the costs of achieving such controls. Any decision regarding EPA action would be based on an evaluation of all these factors.

I. THE OZONE DEPLETION ISSUE

Ozone is found throughout the stratosphere, which is 10 to 50 kilometers above the earth's surface. Ozone is important because it limits the amount of solar ultraviolet radiation reaching the earth, specifically in the wavelength region of 290-320 nanometers (UV-B), which has been correlated to acute effects (e.g., sunburn) and nonmelanoma skin cancer among certain human populations. The concentration of ozone present in the stratosphere is determined by a dynamic balance between natural processes that produce and destroy ozone. Based on theoretical atmospheric models, it is postulated that the rate of ozone destruction and creation can be altered by a buildup in the stratosphere of several chemical species including species containing chlorine (e.g., Cl, ClO), hydrogen (e.g., HO, HO_2, H_2O_2), and nitrogen (e.g., NO, NO_x).

In view of the screening function of the ozone layer, any significant increase in the rate at which chlorine species are injected into the stratosphere is of concern because chlorine atoms and chlorine oxide act as catalysts in chemical reactions that destroy ozone. Chlorofluorocarbons (CFCs)* are very stable in the lower atmosphere. They migrate very slowly from the troposphere across the tropopause and into the stratosphere where they are decomposed by solar ultraviolet radiation and release free chlorine. Consequently, the continued worldwide release of CFCs has the potential to increase chlorine concentrations in the stratosphere, resulting in decreased stratospheric ozone. Increases in chlorine concentrations in the stratosphere have been measured; however, to date, changes in ozone in the

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* Chlorofluorocarbons are a family of chemicals. Historically, CFC-11 and CFC-12 have accounted for about 90 percent of worldwide CFC production. Other commercially important CFCs include CFC-113, CFC-114, CFC-115, and a related compound, CFC-22, which contains hydrogen.

stratosphere beyond natural variations have neither been measured nor expected based on model calculations.

Scientists have developed necessarily simplified atmospheric models (computer simulations) of the complex chemical, transport, and radiative processes in the atmosphere to describe and predict potential stratospheric changes. These models are limited by the quality and extent of data on actual atmospheric levels of the species of interest.

A Workshop on the Stratosphere sponsored by the National Aeronautics and Space Administration (NASA) and the World Meteorological Organization (WMO) was held in May 1981. At the workshop, scientists reported on computer model results, using the most recent chemical reaction rate data (derived from laboratory experiments). Present central estimates of their various computer model calculations are that continued emissions at present levels of CFC-11 and CFC-12 may eventually result in "steady-state" ozone depletion of 5-10 percent. In other words, assuming world CFC emissions continued at present levels into the future, current models show that the existing balance between ozone-creating and ozone-destroying processes in the stratosphere would be changed in such a way that a new equilibrium, or "steady-state", would be achieved near the end of the 21st century and that the total amount of stratospheric ozone would be 90-95 percent of what it is today. If other halocarbons at their present emission rates are included in the models, the "steady-state" depletion is calculated to increase by a third (e.g., a calculated "steady-state" depletion of 6 percent for CFC-11 and CFC-12 would increase to 8 percent when other halocarbons are considered). Workshop participants noted that substantial uncertainty remains with respect to some atmospheric chemical reactions.[1] The final report from this workshop was issued in February 1982.

The models have also been used to estimate the globally-averaged depletion of stratospheric ozone that may have occurred to date due to CFCs; these estimates show it to be less than 1 percent. Using these models, the 5 to 10 percent "steady-state"

depletion calculations imply that continued emissions of CFC-11 and CFC-12 at current levels are calculated to result in an ozone depletion rate of less than about 0.1 percent per year. If this rate of change is correct, taking the time for additional and improved measurements of stratospheric ozone and for the development of other information may not result in significant incremental risk.

Statistical analysis of data from ground monitoring stations, known as ozone trend analysis, is done to detect trends in total global ozone. This analysis indicates the absence of any statistically significant trend in total global ozone over the last decade. This result is not inconsistent with atmospheric model calculations. A recent assessment indicates that the current network of ground-based monitoring stations may be sensitive enough to detect as little as a 2-4 percent change per decade in total ozone. [1]

In addition to CFCs, scientists are investigating other chemical substances including methyl chloroform, nitrogen oxides, and carbon dioxide (CO_2) for their effects on ozone.

EPA has completed an analysis of production and emissions of methyl chloroform.[2] Domestic production was 625 million pounds in 1978, increasing at an average of 16 percent annually between 1974 and 1978. Worldwide production totalled 1.05 billion pounds in 1978, increasing at about a 30 percent annual rate between 1974 and 1978. Analysis of the relative ozone depletion potential of various substances by Lawrence Livermore National Laboratory modeling studies indicates that methyl chloroform has, on a pound per pound basis, about one-seventh (0.14) the potential of CFC-11 for depleting stratospheric ozone.[3] Methyl chloroform is presently included in a proposed EPA rule that would limit emissions of certain degreaser substances from new, modified, and reconstructed organic solvent cleaners.[4]

Nitrogen oxide emissions from aircraft flying at high altitudes (either upper troposphere or lower stratosphere) and carbon dioxide also may affect stratospheric ozone. Atmospheric

model calculations indicate that nitrogen oxides released by subsonic aircraft exhausts in the region of the tropopause may already have increased ozone concentrations by between 0.5 and 1.0 percent. However, as aircraft operate at higher altitudes injecting nitrogen oxides directly in the lower stratosphere, the effect may be to decrease ozone in that region. Significant increases in the number of flights or flight altitudes may be necessary before significant ozone changes would occur.

Increases in carbon dioxide in the atmosphere, due primarily to increased burning of fossil fuels, are expected to lead to decreases in stratospheric temperatures. The consequent slowing of chemical reactions taking place in the stratosphere could make the impact of CFCs on stratospheric ozone less than would otherwise occur without a change in stratospheric temperature. A carbon dioxide buildup may also result in global surface temperature increases and climatic changes of unknown variations.[5]

Although scientists have made great progress in understanding complex stratospheric processes through modeling, laboratory experiments, and atmospheric monitoring, substantial work remains to decrease scientific uncertainties.

A decrease in ozone, independent of other factors, increases the intensity of UV-B reaching the earth's surface. Scientists agree that increased UV-B levels at the earth's surface would increase the incidence of human nonmelanoma skin cancer, especially among light-skinned people. Nonmelanoma skin cancer is a problem primarily because it causes disfigurement and imposes economic burdens associated with its treatment.[6] If detected early, it is usually treatable.

Although the relationship between malignant melanoma, a dangerous form of skin cancer, and UV-B exposure has been studied for over two decades, a dose-response relationship has not been established. For melanoma, total accumulated UV-B dose does not appear to be a significant causal factor, although acute or repeated exposures to sunlight may be important.[6] Melanomas are

increasing at a faster rate than most other cancers especially among younger, more affluent, and better educated persons;[7] however, the relationship between UV-B exposure and melanoma is not known.

Information on nonhuman effects of increased UV-B is presently difficult to quantify. EPA is funding a three-year field research study (through 1983) to determine the effects of increased UV-B on selected economically important crops grown under otherwise normal conditions. Nonagricultural terrestrial organisms have been shown to be susceptible to increases in UV-B exposure. Laboratory studies show that a number of aquatic species (algae, plankton, fish larvae) which exist close to the surface may be living close to their UV tolerance levels. EPA has funded research over the last three years which has provided excellent data on UV-B penetration many meters below the surface in a variety of water conditions.

More detailed information on scientific issues related to stratospheric ozone will be contained in EPA's biennial report to the appropriate House and Senate committees on the results of studies and research conducted by EPA and other agencies. That report, required by Section 153(g) of the CAA Amendments of 1977, is expected to be issued later this year.

To provide for an independent review of the state of knowledge of the impact of man's activities on stratospheric ozone and effects of changes thereto, EPA has requested the National Academy of Sciences (NAS) to consider the most recent scientific developments and to reassess the status of the ozone depletion theory, measurements of ozone and trace contaminant concentrations, and health and environmental effects. A draft report of the NASA/WMO May 1981 workshop along with other requested reports and materials has been made available to NAS for use in their overall assessment of the issue. The EPA contract with NAS requires a report in December 1981, but EPA has modified the contract to assure that NAS has adequate additional time to provide a thorough assessment. The report is now

II. THE AEROSOL RULE

In 1978, EPA and FDA simultaneously published rules prohibiting the use of CFC aerosol propellants in nonessential applications.[8] The final EPA rule prohibited the manufacture of fully halogenated chlorofluoroalkanes for nonessential aerosol propellant uses after October 15, 1978. In addition, the rule prohibited after December 15, 1978 the processing and distribution of bulk CFCs in commerce, the processing for export, and the importation in bulk for aerosol propellant uses or as a propellant in nonessential aerosol articles.

Under the Federal Food, Drug, and Cosmetic Act, FDA prohibited the manufacture or packaging of food, drugs, medical devices, and cosmetic products containing fully halogenated chlorofluoroalkanes as an aerosol propellant after December 15, 1978, and the initial introduction into interstate commerce of finished food, drugs, medical devices, and cosmetic products containing these substances after April 15, 1979. The FDA rule exempted certain drugs and food products.

In its rule, EPA exempted certain uses determined to be essential on the basis of criteria contained in a support document for the rule.[9] These criteria included the availability of substitutes, the economic significance of the product, the environmental and health impacts of the aerosol product and its substitutes, and the effect on the quality of life if the product or a reasonable substitute were unavailable. Current exemptions to the EPA rule include CFC aerosol propellant applications in conjunction with mining, aircraft operation, national defense, pesticide use, manufacture and servicing of electrical and electronic equipment, and mold release agents. The exemption for mold release-agents included spinnerette release-agents which are used in the production of manmade fibers. In January 1981, EPA promulgated a rule, effective March 1982, revoking the spinnerette exemption.[10] Based on new information submitted to the Agency indicating that substitutes for all uses will not be

available by the effective date, EPA restored the exemption. In a recent action, EPA granted a temporary exemption for the use of CFCs in automatic pesticide dispensing units for long-term storage of flue-cured tobacco,[11] pending a review of a request for a permanent exemption. EPA has also exempted rotary-tablet press-punch lubricants from the rule.[12] Several applications for exemptions have been denied, including CFC use in fog machines and spray adhesives.[13] EPA is reviewing applications to exempt CFC propellant use in nozzle shield lubricants for inert-gas welding-guns, graphite solid lubricants, and crack detectors for nuclear power plants.

Manufacturers and processors are required to submit annual reports to EPA if they are manufacturing or using CFC propellants for exempted aerosol products. In 1981, EPA's Office of Enforcement has preliminarily reviewed reports from five manufacturers and 45 processors for the calendar year 1980. Data from the reports indicate that aerosol products accounted for about 24.5 million pounds of CFCs in 1980. In comparison, aerosol use accounted for about 448 million pounds of CFCs in 1973.[14]

A study is being conducted for EPA to evaluate the economic impact of the ban on nonessential CFC aerosol propellants. Preliminary results indicate that, in general, the impact on consumers was small as good substitutes were readily available, often at lower cost to the consumer. There appeared to be a negative impact on profits, especially on CFC manufacturers and on small, aerosol fillers. There was also a one-time cost for aerosol product manufacturers and fillers to reformulate and convert to hydrocarbon or carbon dioxide propelled products.[15]

On December 16, 1980, EPA published an interpretive rule, under authority of Section 12(b) of TSCA, requiring individuals to notify EPA of exports or expected exports of substances regulated under Section 6 of TSCA.[16] The rule requires individuals to notify EPA of the first shipment of each year to a given country. EPA in turn will notify the importing countries

of the export of CFCs to that country and the nature of the EPA regulations. Since January 1981, EPA has received reports from 37 companies giving notice of export to approximately 94 countries. These exports include bulk shipments of CFCs and CFCs in mixtures such as in exempted aerosol products.

III. NONAEROSOL USES

Domestic CFC production and use has changed in the last decade. In the U.S., a sharp drop in CFC production followed a peak of about 1.1 billion pounds in 1974.[14] 1980 production of about 835 million pounds nearly equalled the 1979 domestic output of about 838 million pounds. Since 1974, there has been a decrease in aerosol propellant uses of CFCs from over 400 million pounds to about 24.5 million pounds in 1980. This decrease in CFC production for aerosol uses has been accompanied by an increase in nonaerosol uses. Nonaerosol uses grew about 9 percent annually from 1975 to 1979 and then fell slightly in the 1979-80 economic slowdown.[14,17] Anticipated recovery of the economy combined with expected market growth in the use of CFCs for solvents, food freezing, and other applications may lead to an increase in production over the 1974 peak.[18]

Concern about expected growth in nonaerosol uses, combined with the conclusions of the 1979 NAS report, prompted EPA to consider the need for further Agency action to control CFC emissions. EPA published an Advance Notice of Proposed Rulemaking (ANPR) in October 1980.[19] The objective of the ANPR was to notify the public that EPA was requesting comment about possible effects on human health and the environment resulting from continued use of CFCs and on the economic aspects of the issue. The ANPR served as a tool to gather information from the public on the validity of the ozone depletion theory and other scientific issues, the effectiveness of restricting the use of CFCs as a means of dealing with any significant problem, and international aspects of the issue. The Agency was particularly interested in gathering information on economic impacts and the concerns of small businesses.

EPA received over 2,000 comments on the ANPR. From these comments, it is clear that many segments of industry consider regulatory action to be unnecessary at this time and the regulatory strategies discussed in the ANPR to be

controversial. The Agency believes that many of the issues raised in these comments deserve further analysis. The quality of the comments indicates that the ANPR has succeeded in promoting informed public participation in the evaluation of the issues and an exchange of information among government, industry, and other interested parties.

IV. INTERNATIONAL PRODUCTION AND COOPERATION

Worldwide production of CFC-11 and CFC-12 peaked in 1973-1974. As in the U.S., there was a significant drop in worldwide aerosol use in recent years but growth continued in nonaerosol uses. In 1979, the member nations of the European Economic Community (EEC) accounted for 34.0 percent of total world sales of CFC-11 and CFC-12, the U.S. accounted for 25.5 percent, and the rest of the world totalled 40.5 percent.[20]

Many CFC producing and using nations have taken steps to reduce CFC emissions. The ten members of the EEC are required by an EEC Council decision to cap production capacity for CFC-11 and CFC-12 and to reduce aerosol propellant uses of these CFCs by at least 30 percent of 1976 levels by the end of 1981. Several member countries have achieved significantly greater reductions in aerosol uses than the required 30 percent. Japan has decided to cap production capacity informally with end results equivalent to those of the EEC. Canada, Sweden, and Norway have banned most aerosol propellant uses of CFC-11 and CFC-12, and many other countries have achieved significant reductions without regulation.

A number of international organizations are active in the CFC issue. The Organization for Economic Cooperation and Development (OECD) through its Environment Committee is reviewing the CFC issue and preparing a report on the current status of the atmospheric science, potential UV effects, industry facts and figures, and actions by members and international organizations. In a related exercise, scientists in several countries are using an agreed upon set of CFC emission scenarios in atmospheric modeling studies. The results of this scenario work will be particularly useful for evaluating the effects on eventual ozone depletion of alternative emission control strategies. In the U.S., modelers at Du Pont and Lawrence Livermore National Laboratory are participating in this effort, which is being coordinated by EPA. The results are intended for use by OECD and national policy makers.

The United Nations Environment Program (UNEP) serves as the coordinator and evaluator of international research on the scientific issues. UNEP, through its Coordinating Committee on the Ozone Layer (CCOL), conducts an annual scientific assessment of the ozone depletion issue. CCOL has agreed with the World Meteorological Organization (WMO) suggestion that satellite measurements be integrated with ground-based observations to improve ozone monitoring. The group also expressed concern at increases in nonaerosol uses of CFCs and production of other potential ozone depleters. In May 1981, the UNEP Governing Council agreed to a Swedish proposal to begin work on a global convention to protect stratospheric ozone. The first meeting of the legal/technical group working on the convention was held in Stockholm, Sweden in January 1982.

Other groups active internationally include the World Health Organization, which is participating in an epidemiological study of skin cancer and other potential UV-related health effects; the International Committee of Scientific Unions, which is concerned with biological effects of UV radiation and the overall scientific issues; and the WMO, which is involved in the atmospheric science. The Chemical Manufacturers Association, through its Fluorocarbon Program Panel (an international group), continues to sponsor experimental research related to improving the understanding of atmospheric processes, and annually publishes world production and emissions information for CFC-11 and CFC-12.

Resolution of the domestic control issues will consider the potential for cooperative action with other nations. It is anticipated that continuing cooperation to examine various scientific and policy issues in international fora will lead to better understanding and development of international responses to the problem.

V. FURTHER REGULATION OF CFCS

EPA will conduct a thorough review (including the upcoming NAS assessment) of the available scientific evidence before making policy decisions about further control of CFCs. The current calculated rate of stratospheric depletion of ozone and moderation of growth in CFC uses in the U.S. and the world may allow for scientific research and monitoring activities to continue in order to decrease uncertainties and increase knowledge while not incurring potentially large impacts on stratosphere ozone. Any further Agency action will be based on credible scientific evidence and sound economic analyses subject to rigorous peer review.

EPA is working closely with other agencies to coordinate the exchange of research and information and to review potential responses to the issue by EPA and the other agencies. Agencies involved in this effort include FDA, Consumer Product Safety Commission, Department of Commerce, Small Business Administration, Department of State, and Department of Energy.

In June 1980, EPA published a proposed rule under Part A of the CAA that would limit emissions of volatile organic compounds and five halogenated solvents (CFC-113, methyl chloroform, methylene chloride, perchloroethylene, and trichloroethylene) from new, modified, or reconstructed organic solvent cleaners.[6] EPA is studying whether these halogenated compounds should be included in a final rule.

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